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 CHAPTER 1
 

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## The heart walls and coronary circulation

The heart is located in the central-left part of the thorax (lying on the diaphragm) and is oriented anteriorly, with the apex directed forward, downward, and leftward. The myocardium and specific conduction system are perfused by the right coronary artery (RCA), the left anterior descending coronary artery (LAD), and the left circumflex coronary artery (LCX) (Figure 1).

### The heart walls and their segmentation: the importance to uniform nomenclature

The left ventricle is cone shaped. Although the limits are imprecise it can be divided, except at the apex, into four walls, named classically septal, anterior, lateral, and inferoposterior (Figure 2).

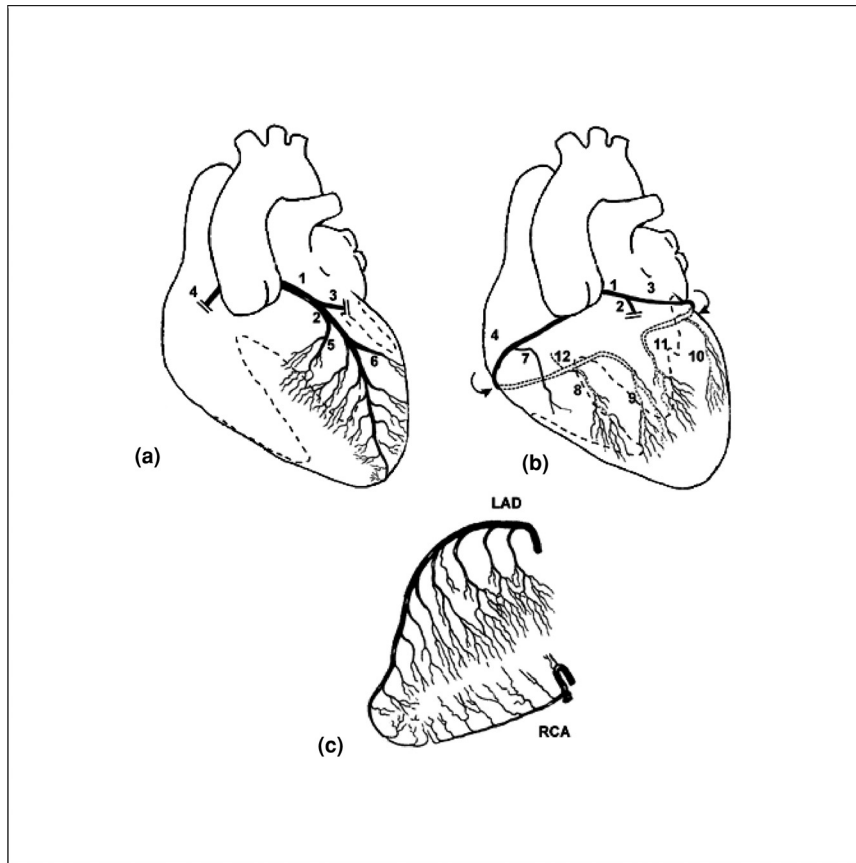
The basal part of the inferoposterior wall often branches upward and then becomes really posterior and for that reason it was named the posterior wall.

For more than 60 years, the terms posterior infarction, injury, and ischemia have been applied when it was considered that the basal part of the inferoposterior wall was affected (Bayés de Luna 1999, Chou Te-Chuan et al. 1977, Goldman 1964, Kennedy et al. 1970, Wagner 2002).

Other names have been given to the walls of the heart (Roberts & Gardin 1978), but the consensus of the North American Societies of Imaging (Cerqueira 2002) divided the left ventricle into 17 segments and 4 walls – septal, anterior, lateral, and inferior (Figures 3 and 4). This consensus states that the classical inferoposterior wall should be called inferior “for consistency” and segment 4 inferobasal instead of posterior. Figures 3 and 4 show the 17 segments into which the four cardiac walls are divided (6 basal, 6 medial, 4 inferior, and the apex), and in the right side of Figure 4 the heart walls with their corresponding segments on a polar “bull’s-eye” map are shown. We believe that this terminology is the most appropriate and facilitates interpretation of the ECG.

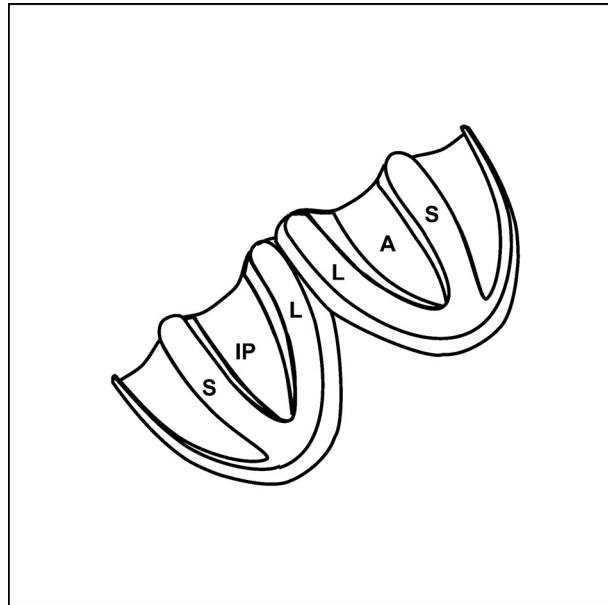
If one considers that the heart is located in the thorax strictly in a posteroanterior position, as is presented in a bull’s-eye polar map or in transverse images by cardiovascular magnetic resonance (CMR) in the case of involvement (injury or necrosis) of the basal part of the inferior wall (classically called posterior wall), the necrosis vector in a sagittal view would be directed strictly posteroanteriorly. This would produce an RS (R) morphology in  $V_{1-2}$  and the injury vector

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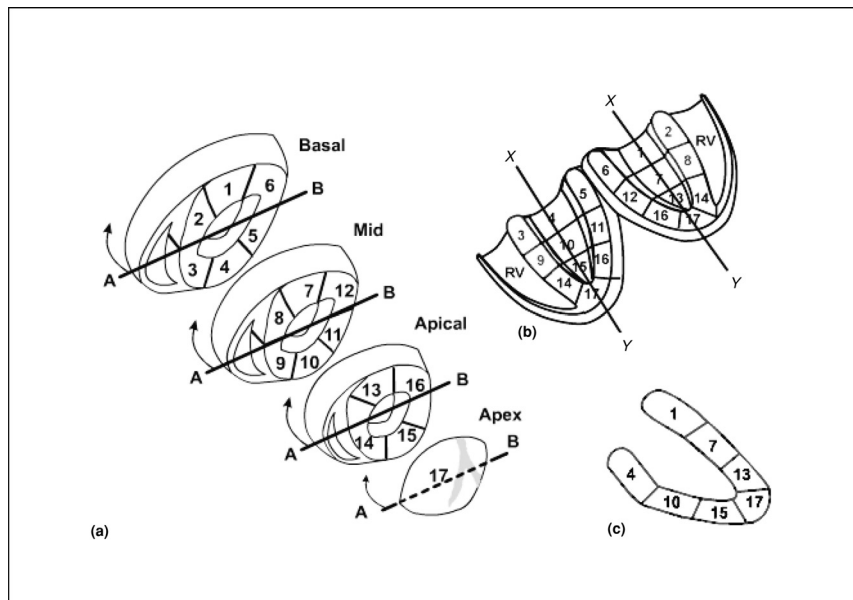


**Figure 1** Coronary circulation: (a) territory of the LAD; (b) territory of the RCA and the LCX; (c) septal perfusion. The anterior part is perfused by the septal branches of the LAD and the inferior part by the septal branches of the posterior descending coronary artery (RCA or, less frequently, LCX). Numbers refer to the following elements: (1) left main trunk; (2) LAD; (3) LCX; (4) RCA; (5) first septal branch ( $S_1$ ); (6) first diagonal branch ( $D_1$ ); (7) RV branch; (8) posterior descending from the RCA; (9) posterolateral from the RCA; (10) obtuse marginal (OM) from the LCX; (11) posterobasal from the LCX; (12) AV node branch (RCA).

would be registered as ST-segment depression in the same leads (Figure 5a). However, magnetic resonance imaging (Blackwell et al. 1993, Pons-Lladó & Carreras 2005) provides evidence in vivo that in the sagittal view the heart is oriented with an oblique right-to-left inclination and not in a strictly posteroanterior position (Figure 6). This explains why the RS (R)–ST depression pattern in  $V_1$  is a consequence of necrosis injury of the lateral wall (Figure 5c) and that the involvement of the classically named posterior wall (actually the inferobasal segment of the inferior wall) produces ST depression more evident in  $V_{2-3}$  than in  $V_1$ , and an RS morphology in  $V_1$  (Figure 5b). Other reasons to

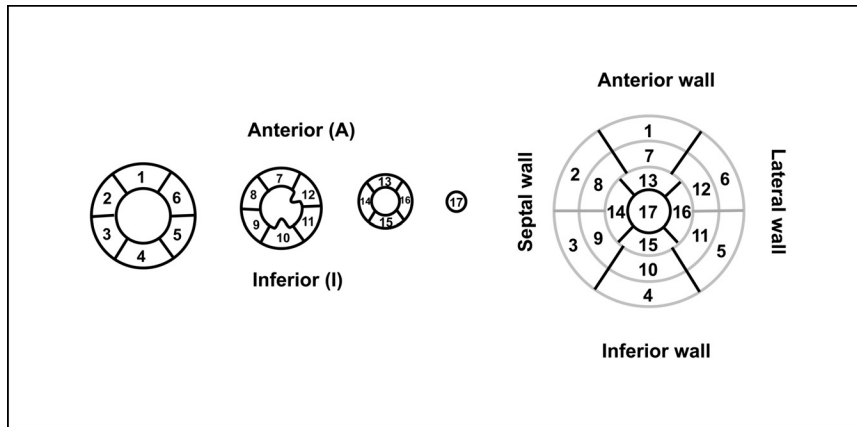


**Figure 2** The left ventricle may be divided into four walls that are named anterior (A), inferoposterior (IP), septal (S), and lateral (L). The inferobasal portion of the inferoposterior wall is usually considered the posterior wall.

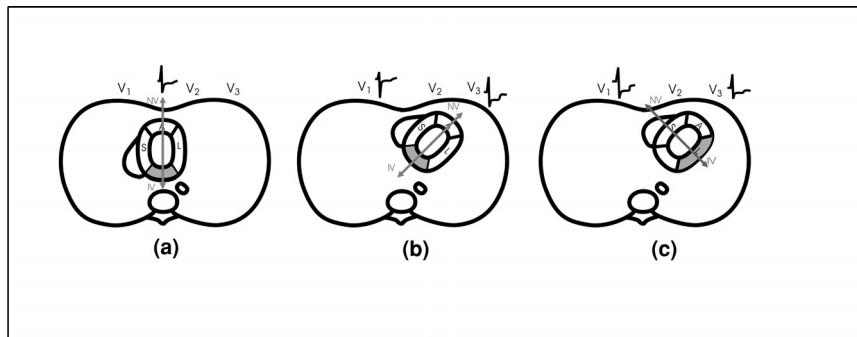


**Figure 3** (a) Segments into which the left ventricle is divided according to the transverse sections performed at the basal (B), medial (M), and apical (A) levels (Figure 6). The basal and medial sections delineate six segments each, while the apical section shows four segments. Together with the apex, they constitute the 17 segments into which the left ventricle can be divided, according to the classification performed by the American Imaging Societies (Cerqueira 2002). View of the 17 segments with the heart open in a longitudinal horizontal plane (b) and longitudinal vertical (sagittal-like) plane (c).

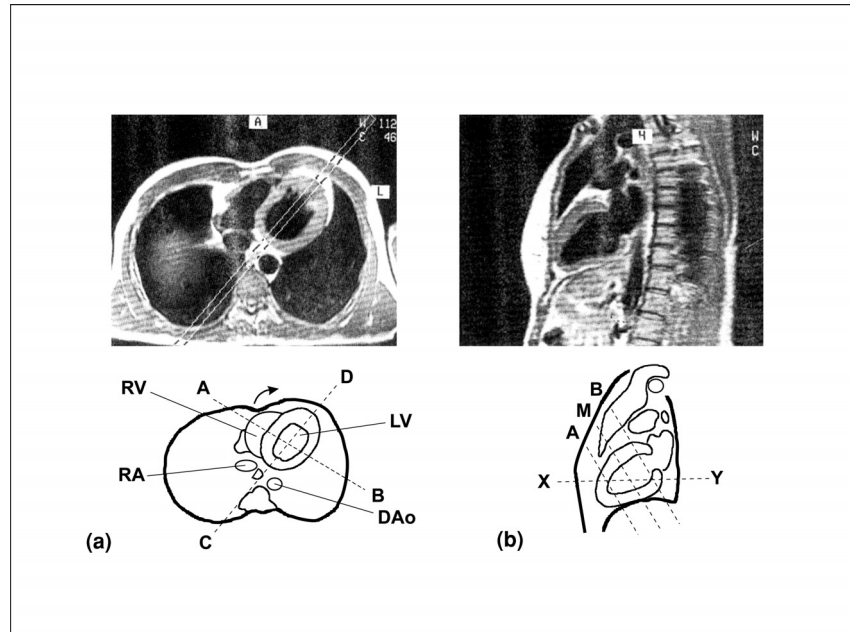
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**Figure 4** Images of the segments in which the left ventricle is divided according to the cross sections at the basal, medial, and apical levels, considering that the heart is located in the thorax strictly in a posteroanterior position. Segment 4 (inferobasal) was classically named the posterior wall. The basal and medial sections delineate six segments each, while the apical section shows four segments. Note in the middle section the location of the papillary muscles. To the right are all 17 segments in the form of a polar map ("bull's-eye"), just as it is represented in isotopic images.



**Figure 5** (a) False location of the heart in the thorax. This results from the extrapolation of the classical concepts expressed in the majority of ECG books and the images used by the imaging specialists (Figure 4). According to that, the injury vector (IV) and necrosis vector (NV) that present approximately in the same direction, but in opposite directions, would explain the RS morphology with ST-segment depression observed in  $V_1$  in the case of STEMI, mainly affecting the inferobasal segment (classically posterior wall). However, according to the true heart position in the thorax (b and c), the RS morphology with the largest ST depression in  $V_1$  is explained mainly by the involvement of the lateral wall. (c) When the inferobasal segment is involved, the morphology in  $V_1$  is RS, with smaller ST depression in  $V_1$  than in  $V_3$  because in this case the IV and NV point toward  $V_3$  and not  $V_1$  (b).



**Figure 6** Magnetic resonance imaging. (a) Location of the heart within the thorax, according to a section in the thoracic axial plane (at the level of the line “XY” of b). (b) Note that this longitudinal vertical section presents an oblique direction from backward to forward and from the right to the left (sagittal like) (see line CD in part a) and therefore corresponds with Figure 5b and c and not with Figure 5a.

eliminate use of the word *posterior* are as follows:

- 1 The posterior wall often does not truly exist because all of the inferoposterior wall lays flat on the diaphragm.
- 2 Even when necrosis exists, it usually does not generate an R in  $V_1$  (Q equivalent) because the inferobasal segment of the inferior wall depolarizes after 40–50 milliseconds.

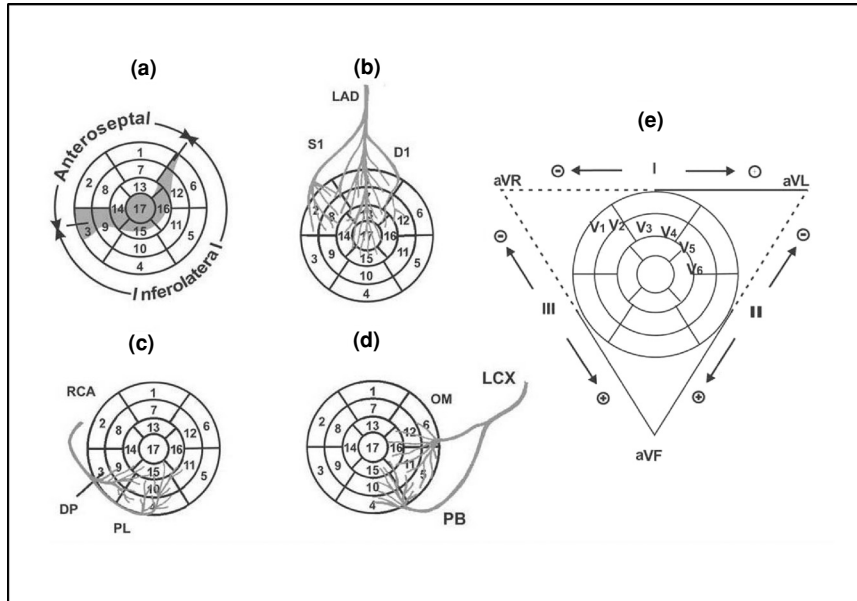
### Coronary circulation: the perfusion of the heart walls

In Figure 7b–d, the perfusion that the different walls with each of their corresponding segments receive from the three coronary arteries can be seen. The areas with common perfusion are colored in gray in Figure 7a. In Figure 7e the relation between the 12 leads of the surface ECG and the four walls of the heart is shown.

#### Left anterior descending coronary artery

The LAD perfuses the anterior wall especially via the diagonal branches (segments 1, 7, and 13), the anterior part of the septum via the septal branches (segments 2, 8, and part of 14; segment 14 is sometimes coperfused by the

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**Figure 7** The perfusion of these segments by the corresponding coronary arteries (b to d) can be seen in the “bull’s-eye” images. According to the anatomical variants of coronary circulation, there are areas of shared variable perfusion (a). The apex (segment 17) is generally perfused by the LAD, but sometimes by the RCA or even the LCX. Segments 4, 10, and 15 are perfused by the RCA or the LCX, depending on which of them is dominant (the RCA in more than 85% of the cases). Segment 15 is often partially perfused from LAD. (e) Location of the 12-lead ECG in relation to the polar map. Abbreviations: D<sub>1</sub>, first diagonal branch; LAD, left anterior descending coronary artery; LCX, left circumflex coronary artery; OM, obtuse marginal branch; PB, posterobasal branch; PD, posterior descending coronary artery; PL, posterolateral branch; RCA, right coronary artery; S<sub>1</sub>, first septal branch.

RCA), and often part of segments 3 and 9 that are also shared with the RCA. Frequently, the LAD perfuses the apex and part of the inferior wall, as the LAD wraps around the apex in over 80% of cases (segment 17 and part of segment 15). Also the right bundle branch is perfused by the first septal branch.

### Right coronary artery

This artery perfuses, in addition to the right ventricle, the inferior region of the septum (part of segments 3 and 9). Segment 14 corresponds more to the LAD, but is sometimes shared by both arteries. The RCA also perfuses a large part of the inferior wall (segments 4, 10 and 15). Segments 4 and 10 can instead be perfused by the LCX, if this artery is of the dominant type (observed in 10% of patients). At least part of segment 15 is perfused by the LAD if the LAD is long. Parts of segments 5, 11, and 16, via the posterolateral branches, are on certain occasions perfused by the RCA, if it is very dominant. Lastly, the RCA

perfuses segment 17 if the LAD is very short. The AV node is usually perfused by the AV node artery, a branch of the posterior descending.

**Circumflex coronary artery**

The LCX artery perfuses most of the lateral wall – the anterior basal part (segment 6), and the mid and low parts shared with the LAD (segments 12 and 16) and often the entire inferior part of the lateral wall (segments 5 and 11) unless the RCA is very dominant. It also perfuses, especially if it is the dominant artery, a large part of the inferior wall, especially segment 4, on occasions, segment 10, and even part of segment 15 and the apex (segment 17).

